Data Compression of High-spectral Resolution Measurements

H.-L. Allen Huang, Bormin Huang

CIMSS/SSEC, University of WI-Madison

Tim Schmit, Roger Heyman

NOAA/NESDIS

Satellite Direct Readout Conference for the Americas

9-13 December 2002

Miami, Florida

Presentation Outlines

- **High-spectral IR Data**
  - What to Expect?
- **High-spectral Data Information**
  - Spectral, Spatial & Temporal Information?
- **High-spectral Data Processing**
  - Why can we Compress Data Effectively?
  - Why can we accept lossy compression?
- **Roadmap for High-spectral Data Processing**
  - Measurement Simulation, Data Compression Study, and tunable lossless/lossy approach

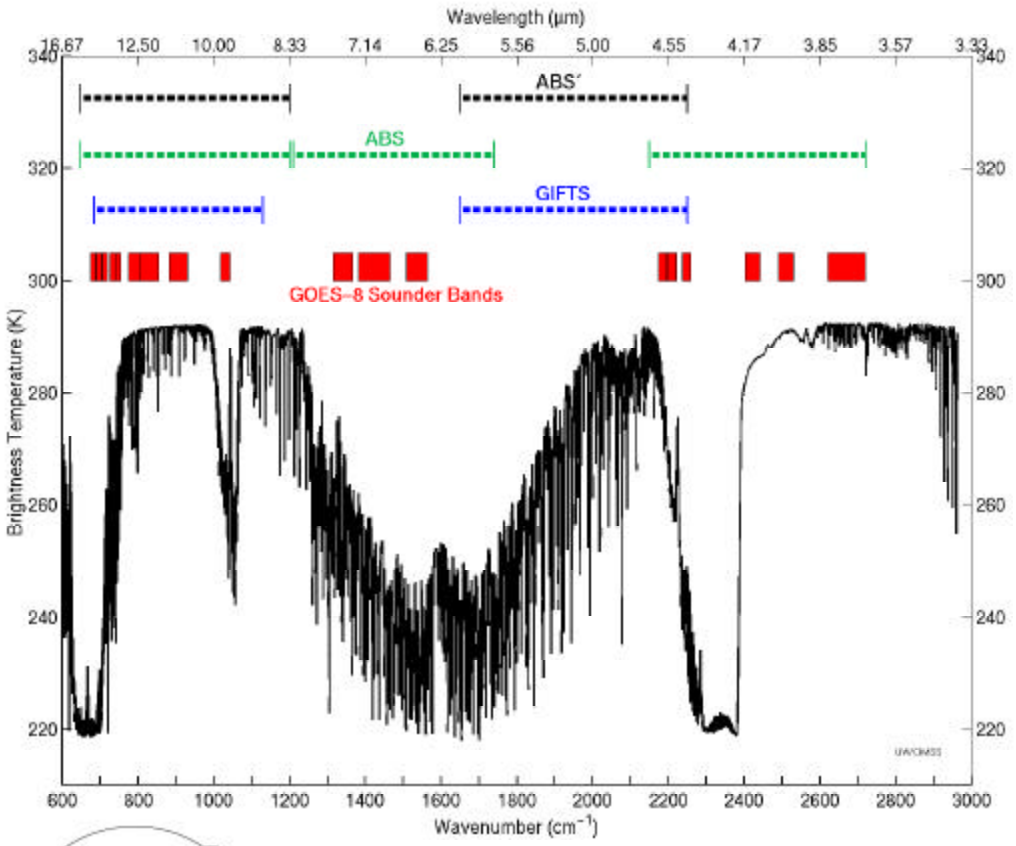
CIMSS

NOAA

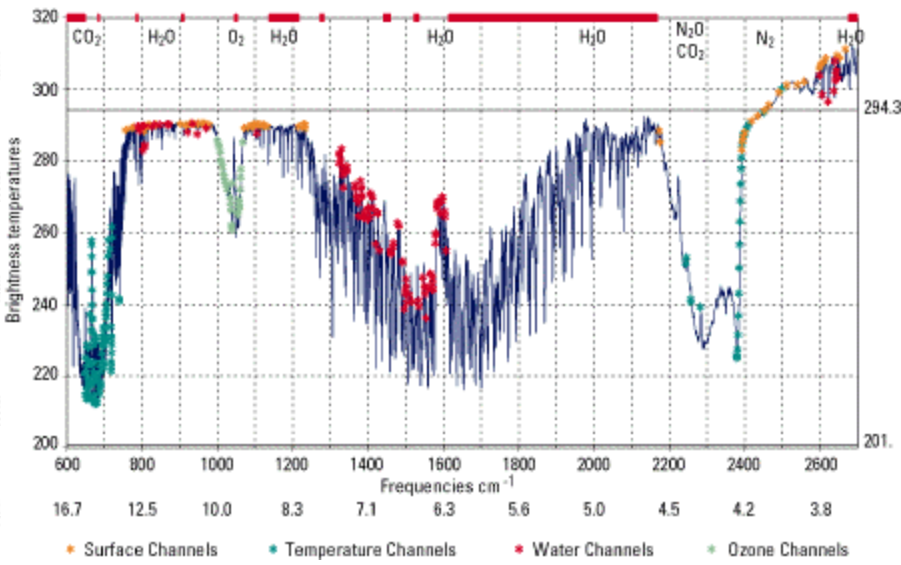
High-spectral resolution IR Data -

What to Expect -> Lots more data than we can handle

HES/GIFTS ~ 2000 ch. per 4-10 km



AIRS - 2378 ch .per 14 km



GOES - 18 ch .per 10 km

CIMSS

NOAA

High-spectral resolution Data Processing -

Why we need Data Compression ->

Too much data for processing, distribution and Archival

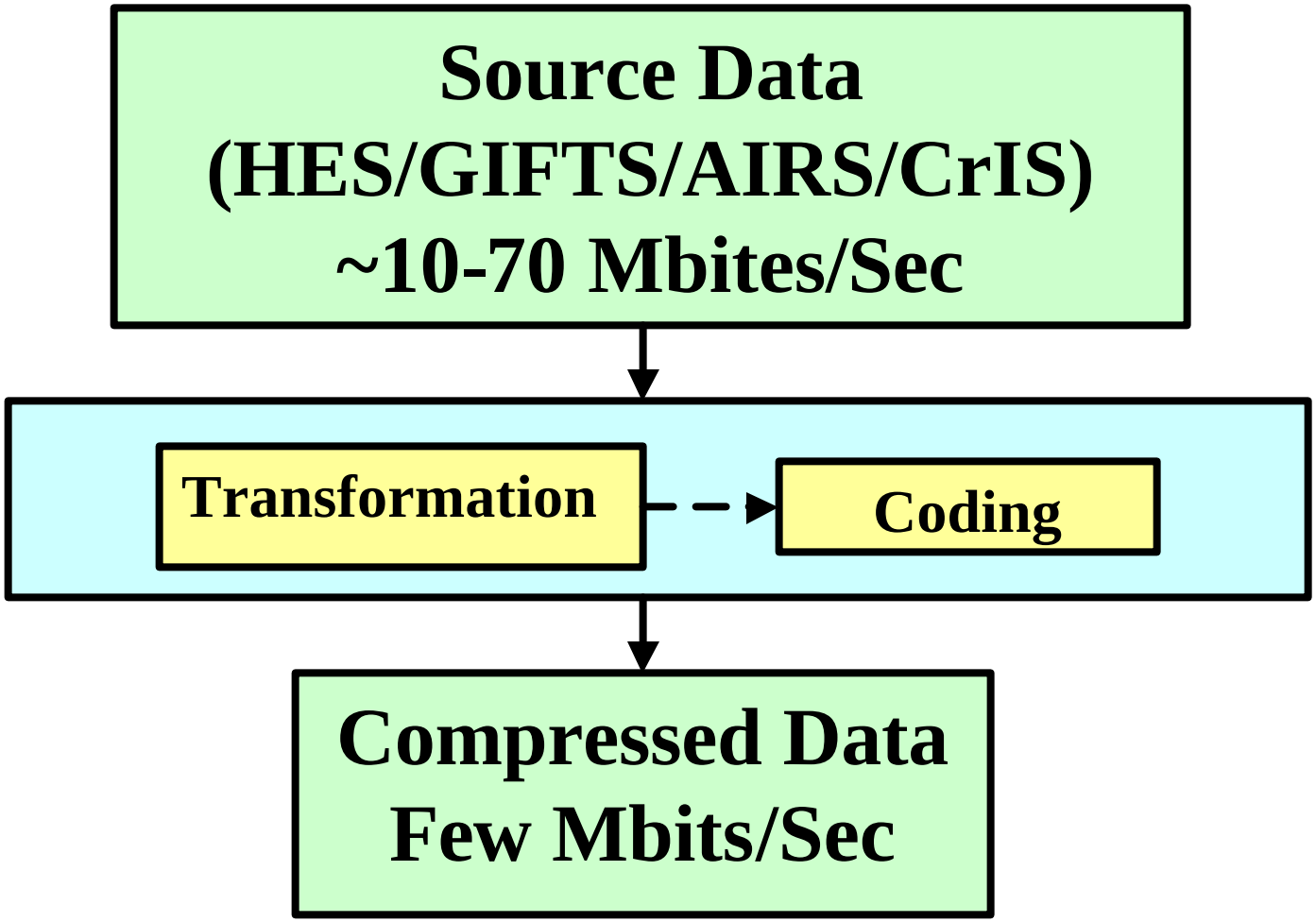
Data Rate/Volume

	#CH	IFOV(km)	Data Rate (Mb/Sec)	Volume (MB/day)
GOES	**18**	**10**	**0.04**	**~97**
HES	**~2000**	**4-10**	**~20**	**~10000**

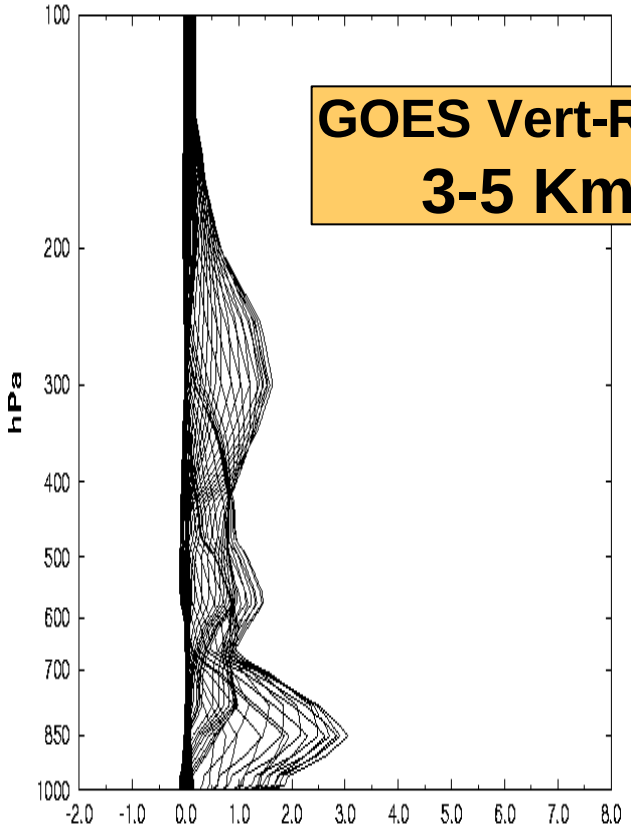
CIMSS

NOAA

High-spectral resolution Data Processing - Spectral Data Compression Approaches ->

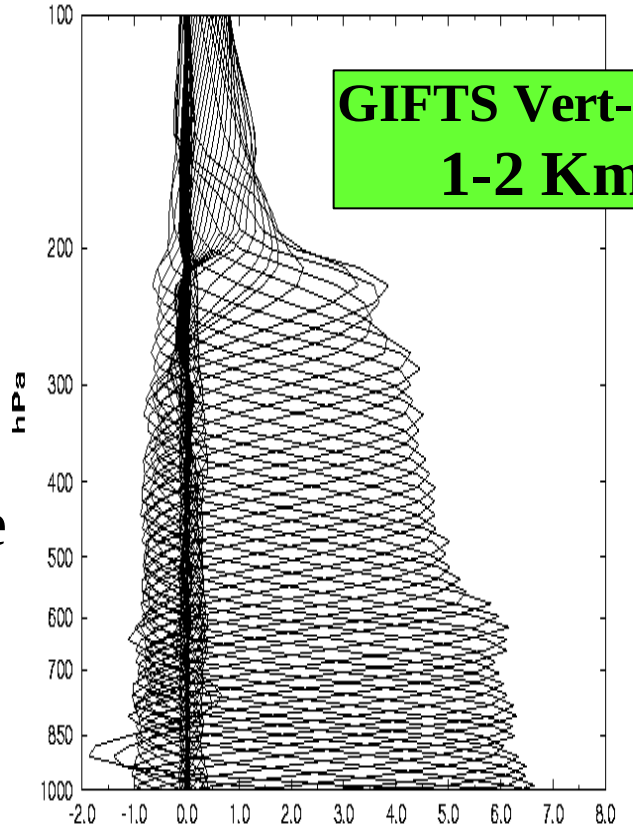


High-spectral resolution Data Information - Spectral Information -> Vertical Resolution



GOES Vert-Res.: 3-5 Km

Temperature



GIFTS Vert-Res.: 1-2 Km

Current - GOES

~3 Pieces

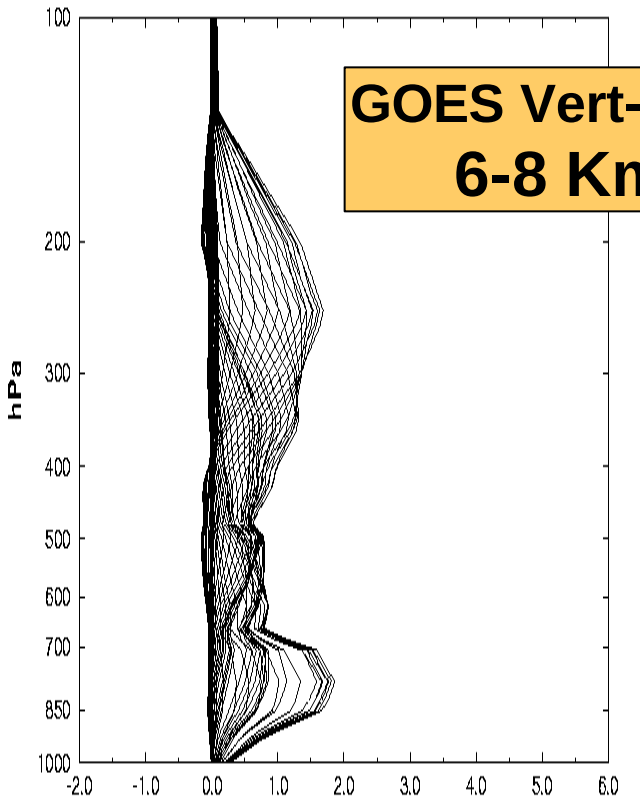
GIFTS

10-12 Pieces

CIMSS

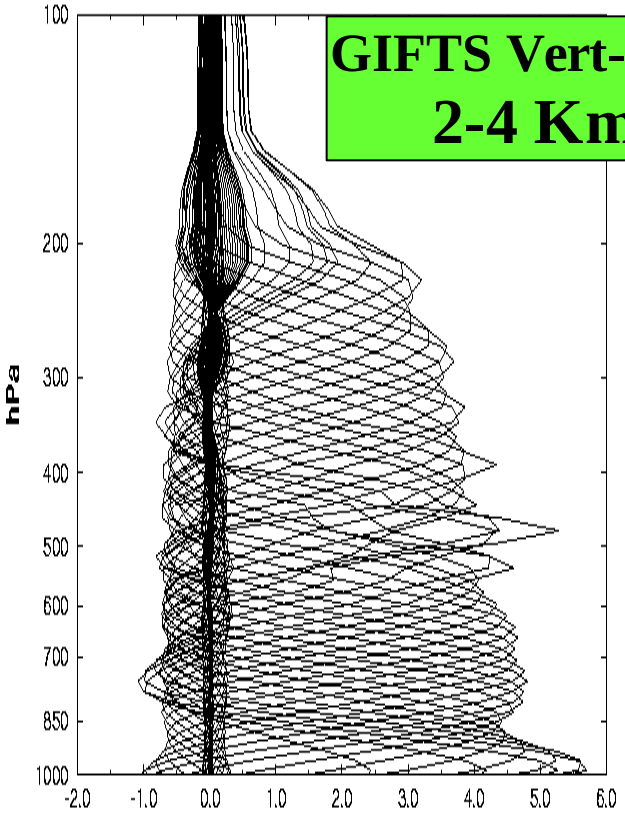
NOAA

High-spectral resolution Data Information - Spectral Information -> Vertical Resolution



GOES Vert-Res.: 6-8 Km

Water Vapor



GIFTS Vert-Res.: 2-4 Km

Current - GOES

~2 Pieces

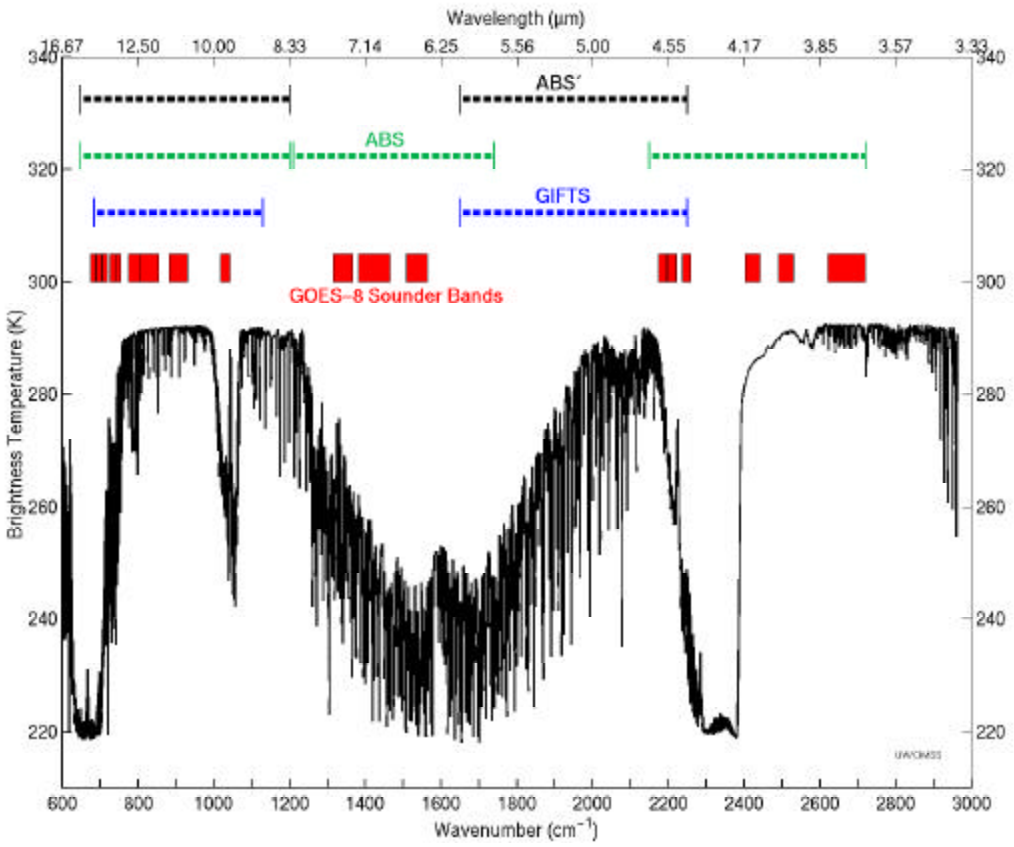
GIFTS

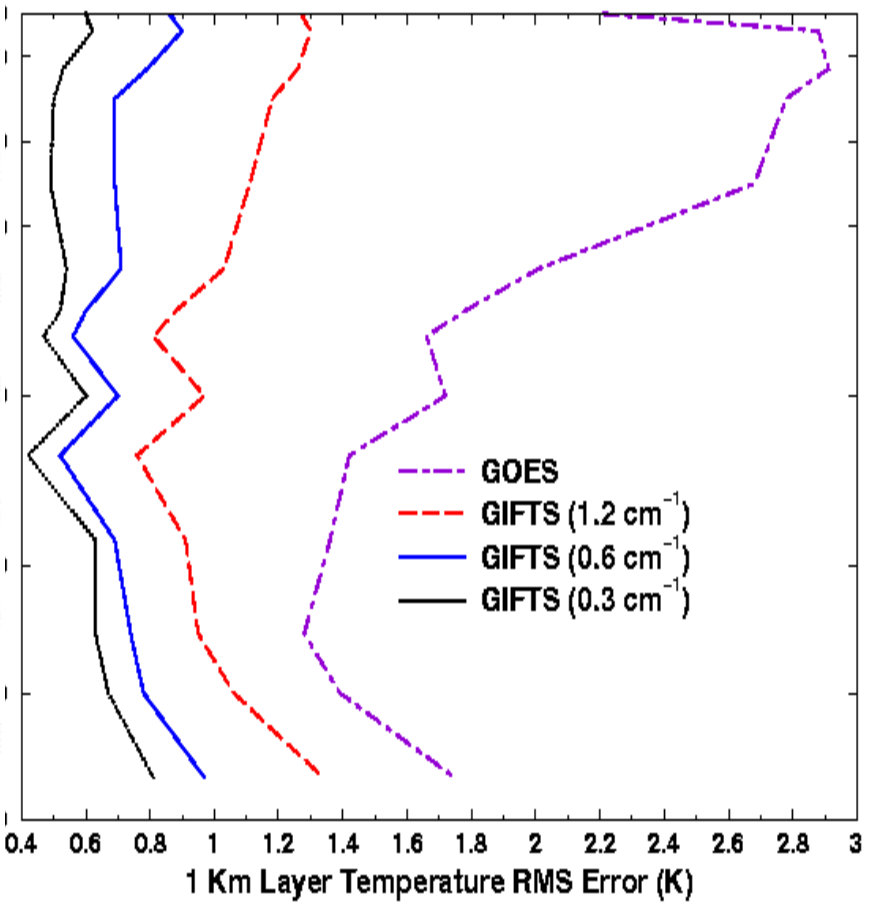
8-9 Pieces

CIMSS

NOAA

High-spectral resolution Data Information - Spectral Information -> Sounding Accuracy

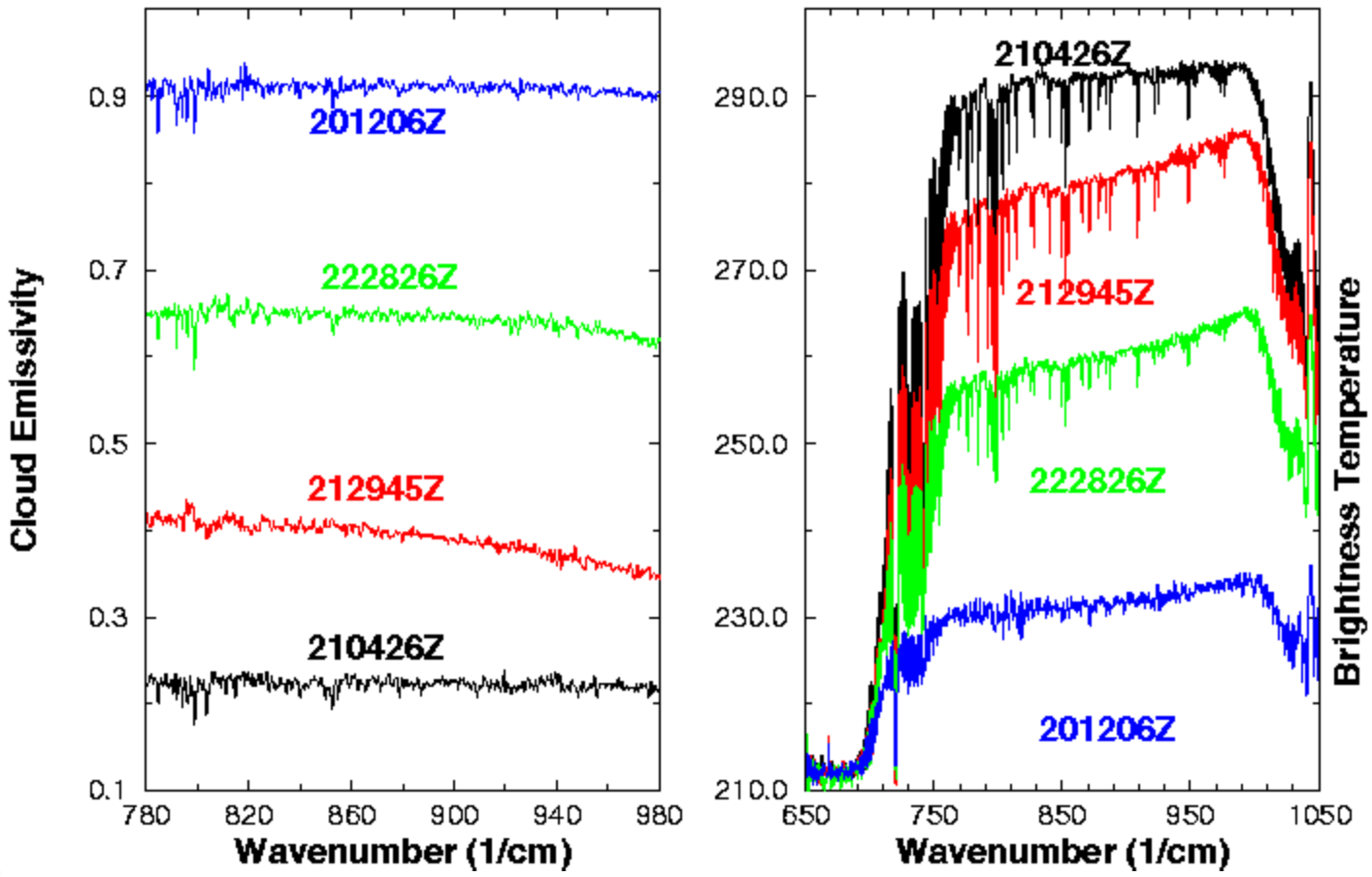




CIMSS

NOAA

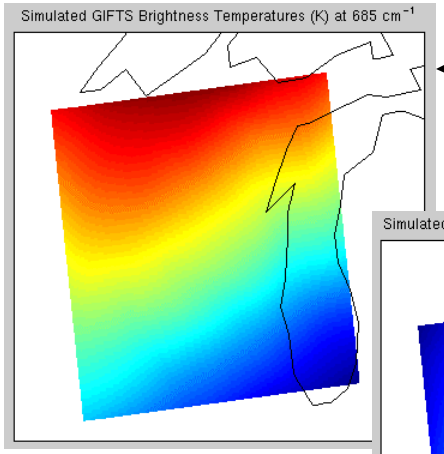
High-spectral resolution Data Information - Spectral Information -> Marco & Micro Cloud Property



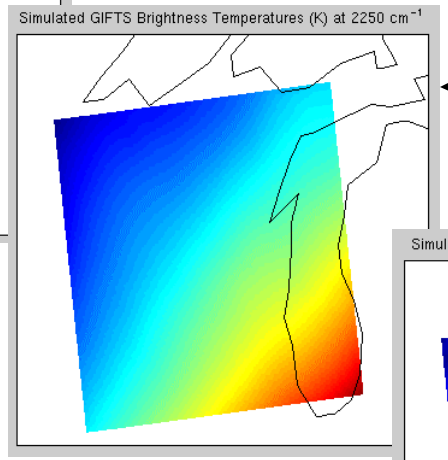
CIMSS

NOAA

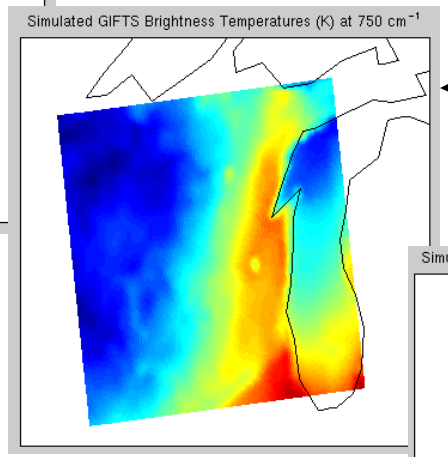
High-spectral resolution Data Information - Spatial Information -> Gradient



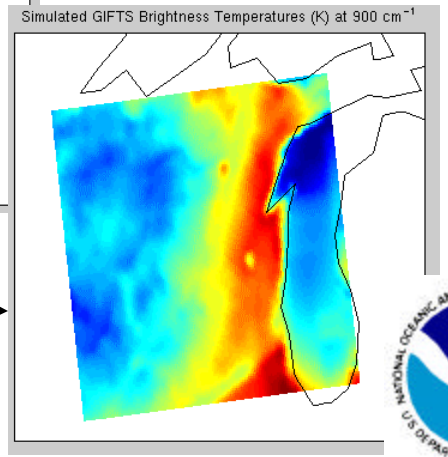
Upper High



Upper Low



Middle



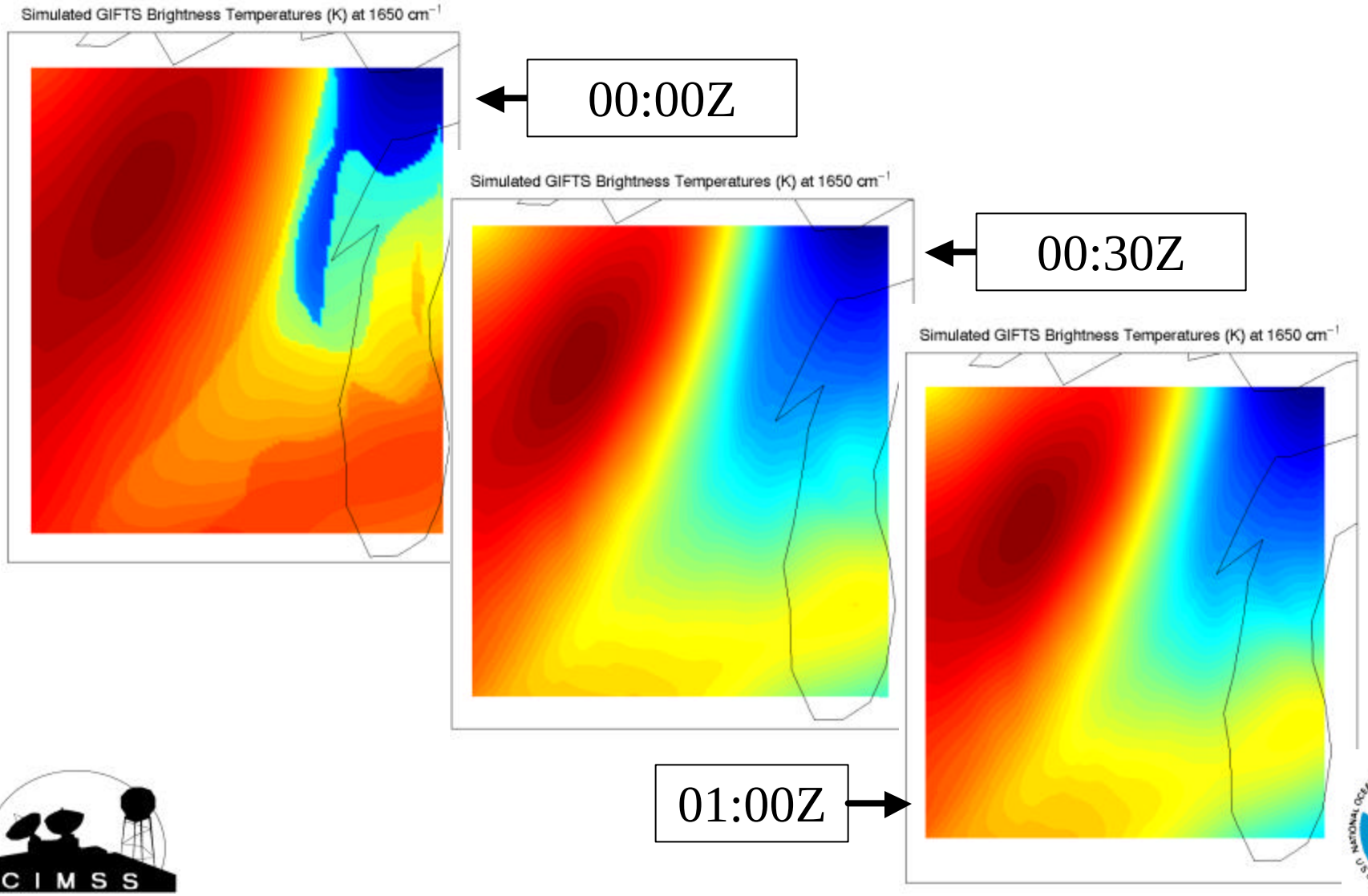
Surface

Mesoscale Vertical & Spatial Thermal Gradient

CIMSS

NOAA

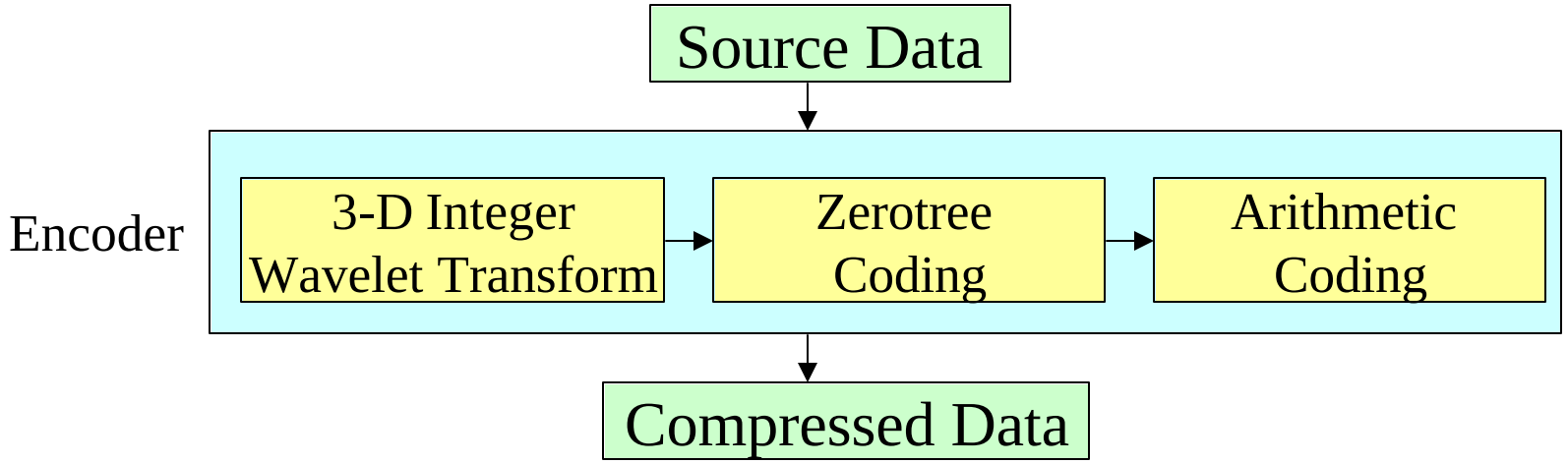
High-spectral resolution Data Information - Temporal Information -> Moisture Transport



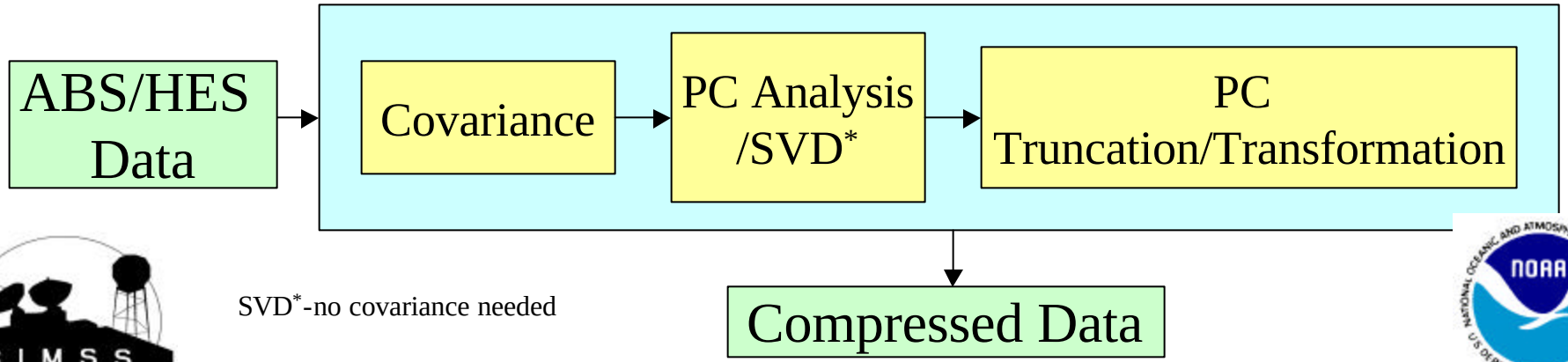
High-spectral resolution Data Processing - Data Compression Approaches ->

To Achieve best Compression within given resource

- **UW Wavelet -On Board/On Ground (tunable Lossless/lossy)**



- **UW DPC - On Ground Only (lossy only)**



SVD*-no covariance needed

High-spectral resolution Data Processing - Wavelet Data Compression ->

Require << $O(N^4)$ of operation for N by N data compression

A wavelet compression scheme rearranges the transformed coefficients in a special tree structure. The data is then entropy-coded.

Applying the (2,2) biorthogonal wavelet compression to two 16-bit ABS test data cubes we have the following lossless compression results:

1. Noisy data (**Simulated; IR longwave; single granule only**):
   Compression ratio=2.05,
   Compressed bit rate=7.80 bits / pixel;
2. Noise-free data ('radNoiseFreeInt16LW_Granule176.bin'):
   Compression ratio=3.34,
   Compressed bit rate=4.79 bits / pixel.

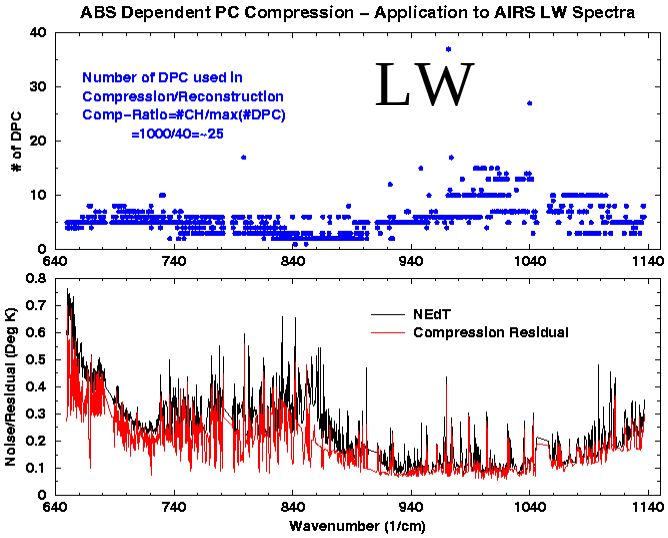
CIMSS

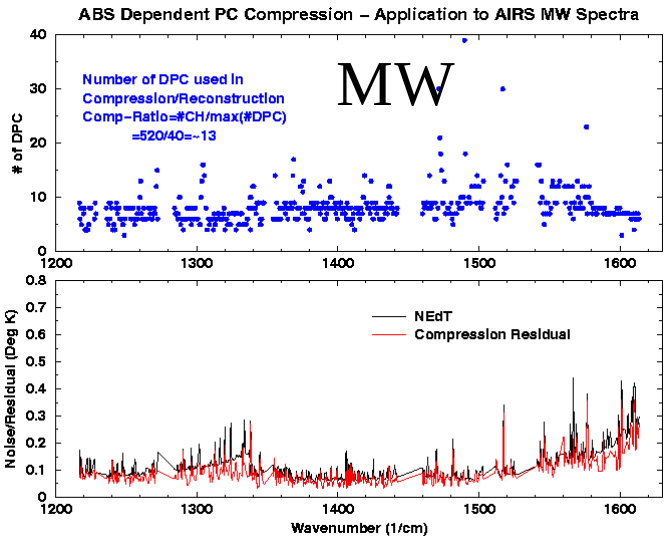
NOAA

High-spectral resolution Data Processing - Dependent PC Lossy Data Compression ->

Require ~O(N^4) of operation for N by N data compression

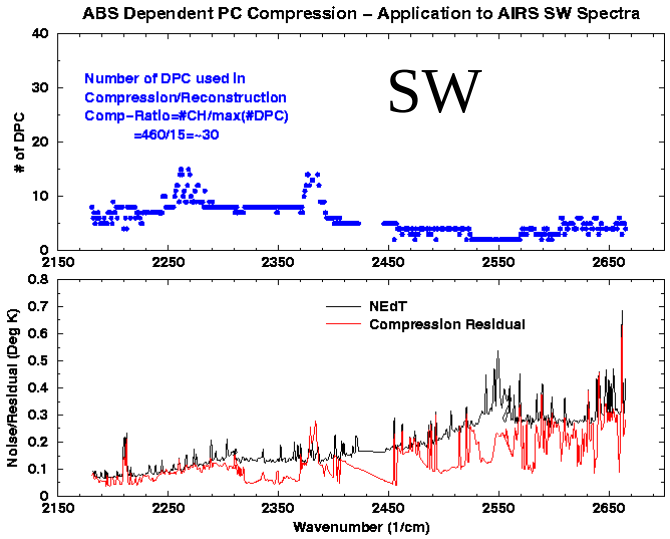
CR=25





CR=13

CR=20

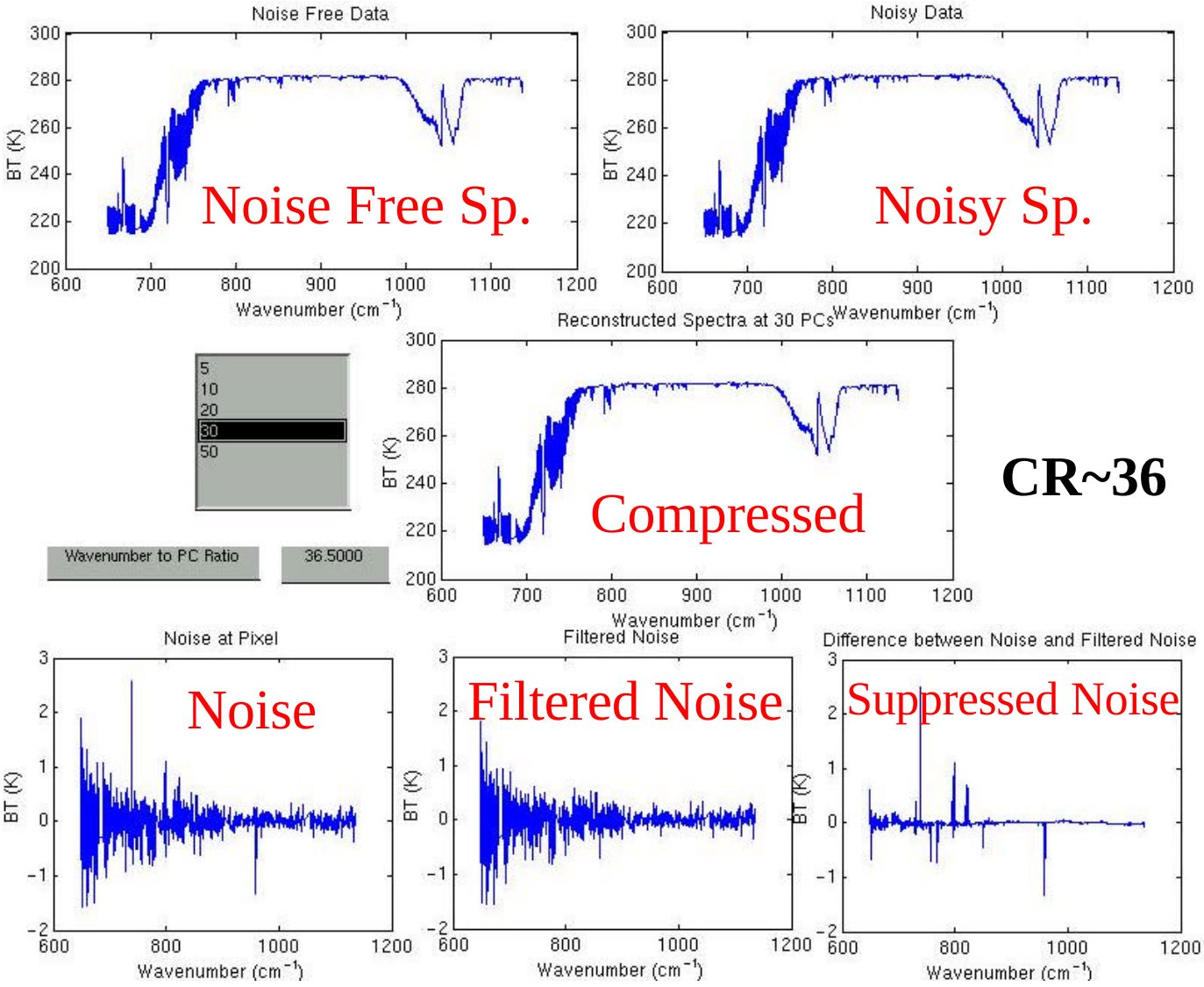


DPC Can Achieve CR of 10-20, but requires significant H/W resources

CIMSS

NOAA

High-spectral resolution Data Processing - Dependent PC Lossy Data Compression ->

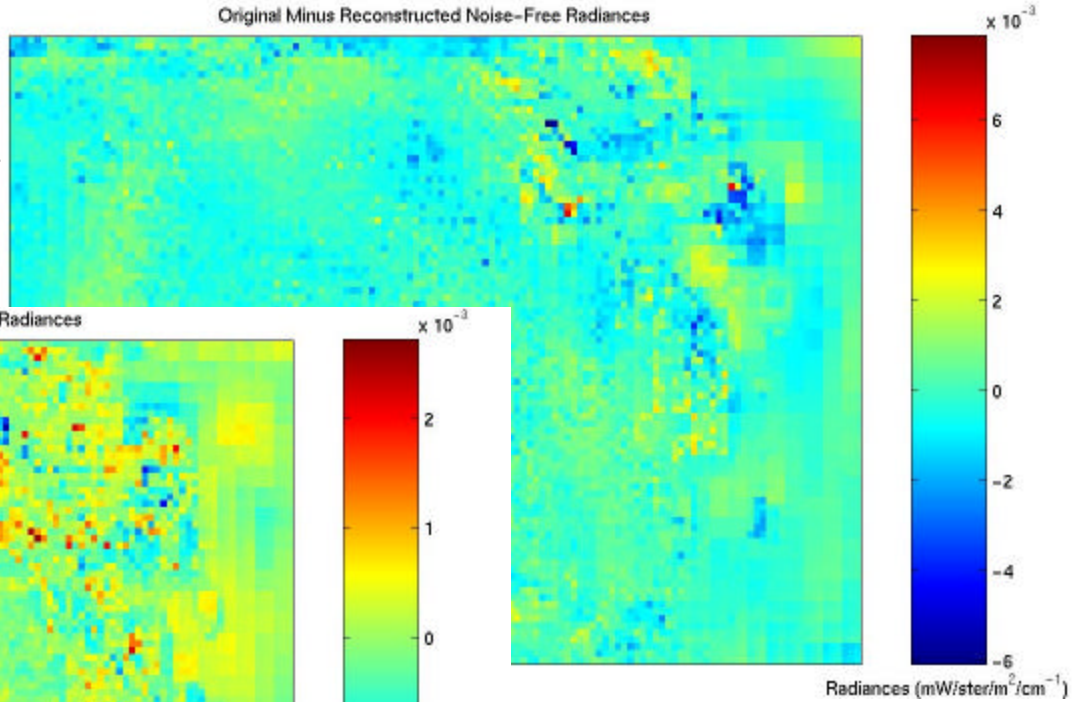


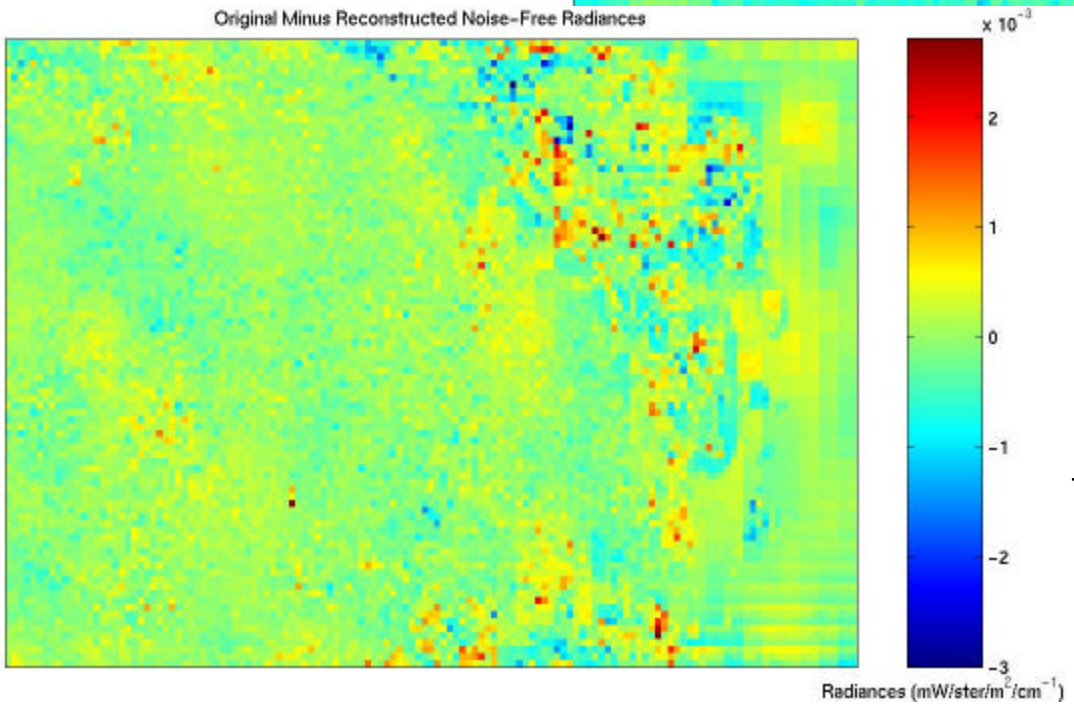
High-spectral resolution Data Processing - Dependent PC Lossy Data Compression ->

Compression loss is mainly "Noise" only

(very little "Signal" loss ~ 10^{-3})

Temperature Ch.
CR=10



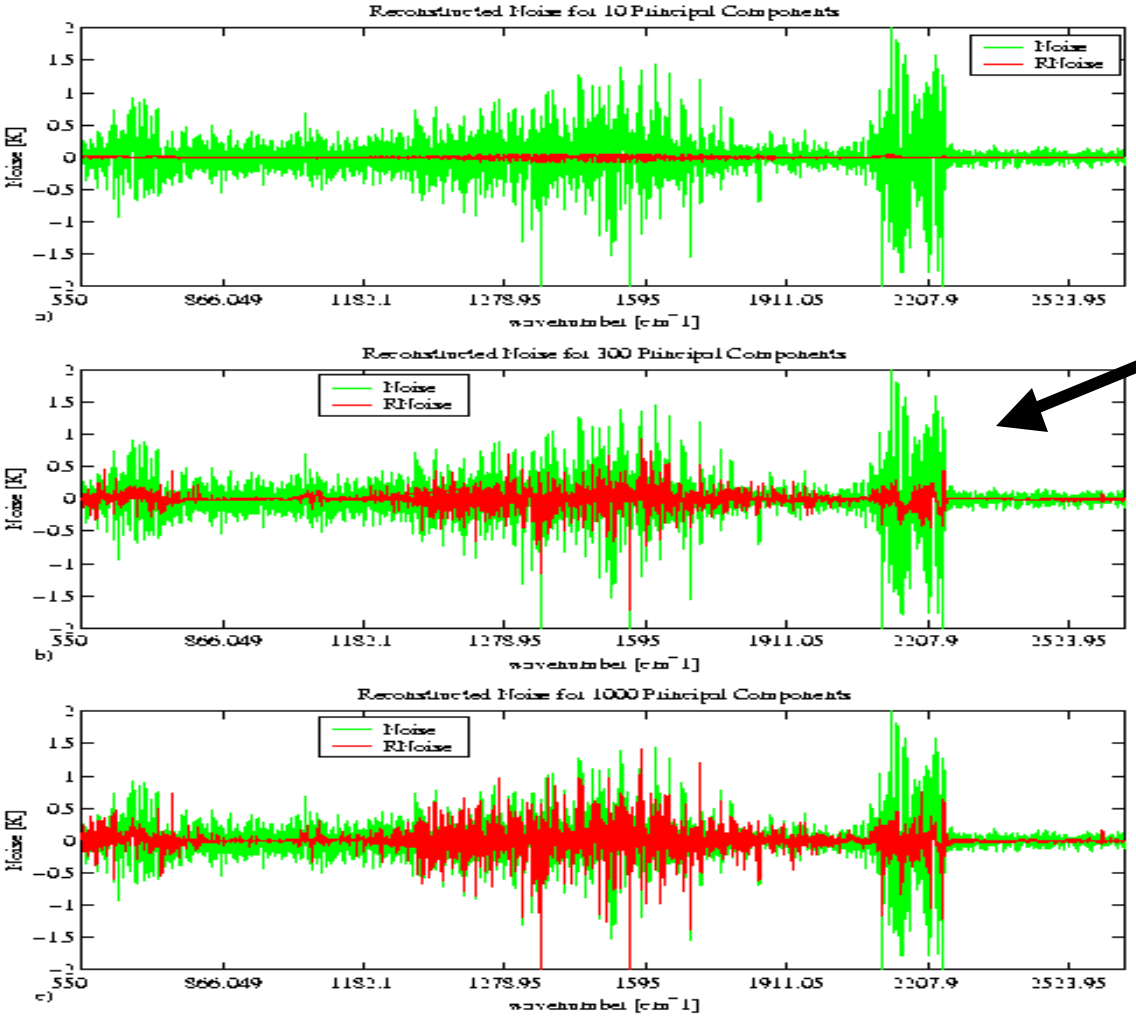


Window Ch.
CR=10

CIMSS

NOAA

High-spectral resolution Data Processing -
Why can we Filter-out Noise Effectively



Noise Suppressed

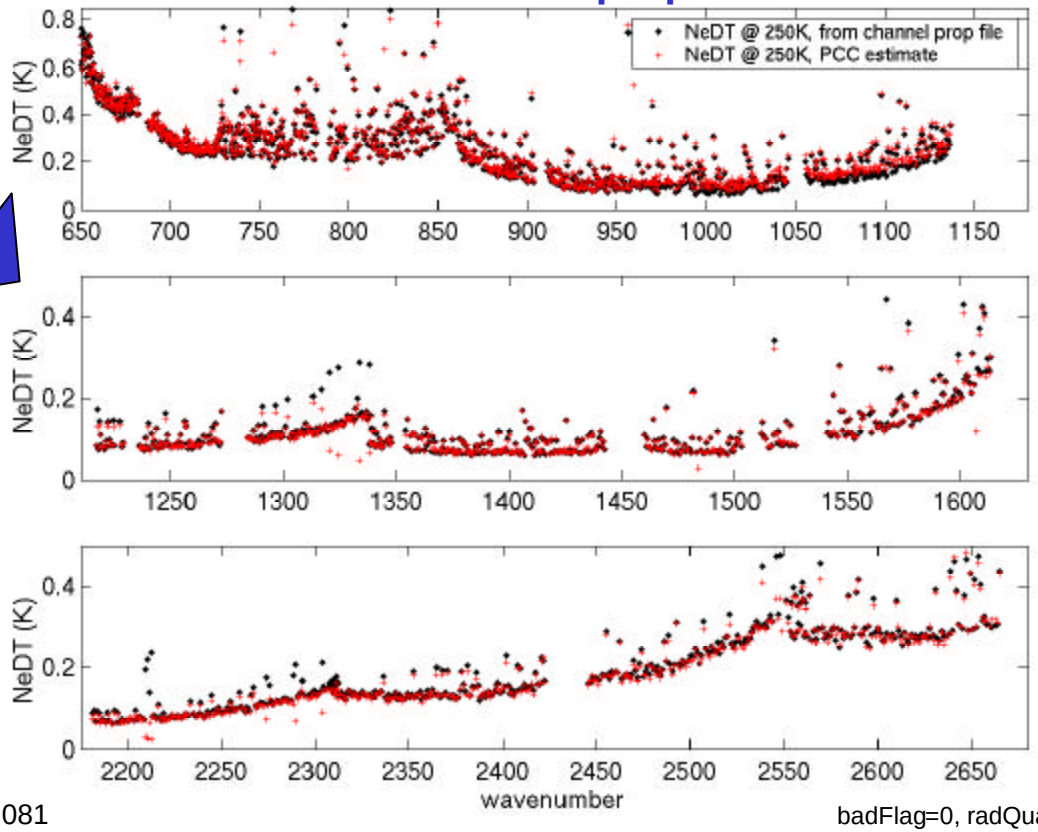
Optimal DPC

Noise Partially Duplicated

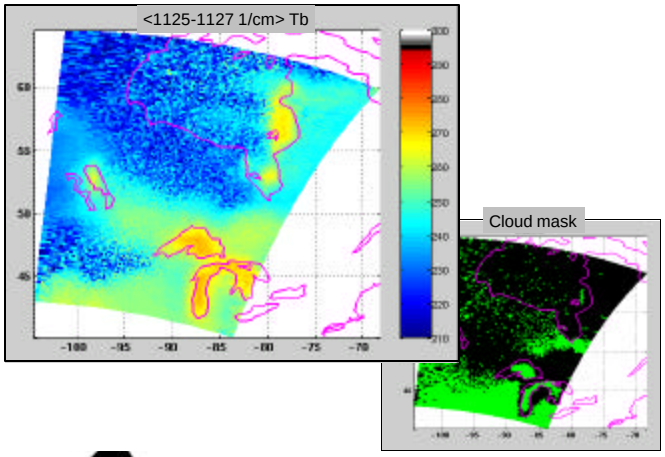
High-spectral resolution Data Processing - Why can we Estimate Noise Effectively -> Noise are Well Estimated

Noise estimated well represent actual measurement noise

NeDT@250K: estimated from granule 081 and values from channel properties file



15-Dec-2000 granule 081



081

badFlag=0, radQual

CIMSS

CURRENT HIGH-SPECTRAL RESOLUTION DATA COMPRESSION STUDY STATUS

CIMSS/UW - Wavelet Lossless (~2)

DPC Lossy (~10-20; tunable) (On-ground only)

NESDIS - IPC Lossy (~10-20; tunable) (On-ground only)

Aerospace - Wavelet Lossless (~2)

Wavelet Lossy (~4-?; tunable)

GSFC - Rice Lossless (~2)

? - under study

Rice Lossy (~4-?; tunable)

CIMSS

NOAA

CURRENT HIGH-SPECTRAL RESOLUTION DATA COMPRESSION STUDY SUMMARY

- **Wavelet/Rice Compression** can achieve **both lossless and lossy** compression effects:

Tunable and can **be implemented** both **in spacecraft and on- ground**

- **Principal Component Compression** can achieve **both sizable lossy compression ratio and suppress/filter-out data noise** (for ground based application only)

CIMSS

NOAA